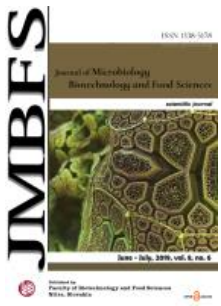

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SYSTEMATIC INVESTIGATION ON PRODUCTION AND QUALITY EVALUATION OF *LUGDI*: A TRADITIONAL ALCOHOLIC BEVERAGE OF HIMACHAL PRADESH, INDIA

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ABSTRACT

The present study was aimed to investigate the traditional process of *lugdi* production, collection of samples and physicochemical analysis of collected samples. The survey revealed that rice (local varieties) or broken rice was used as the main raw material for *lugdi* preparation. It was further observed that *phab* was the only inoculum used to carry out the *lugdi* fermentation. The general production steps in *lugdi* preparation were cooking of rice (time and water can vary according to place), followed by cooling and mixing of powdered *phab*. The physicochemical analysis of collected *lugdi* samples revealed the total soluble solids (TSS) in ranges from 2.5 to 3.9°B, ethanol 4.61 to 5.68%, lactic acid from 0.83 to 1.15%, total phenols from 127.56-168.54 mg/100 mL. Fourier Transform Infrared Spectroscopy (FTIR) of *lugdi* samples also confirmed its richness in protein and phenolic compounds. In nutshell, it is concluded that despite its nutritional and health benefits a wide range of variability has been observed in different samples collected from the same production unit, which should be standardized with the involvement of researchers to get a uniform product.

Keywords: *phab*, rice, ethanol, saccharification, FTIR

INTRODUCTION

Himachal Pradesh (India) is well known for its topography and culture throughout India where the climatic conditions range from semi-tropical to semi-artic; having the altitude from 350 meters to 6975 meters above the sea level. These all lead to a wide variation in the living pattern of the hill folks including their costumes and dialects, food pattern, and celebrations; where a wide range of foods (fermented or non-fermented) are prepared and consumed traditionally to adapt to cold climatic conditions (**Savitri and Bhalla, 2007**). A wide range of fermented foods, both alcoholic (*sur*, *lugdi*, *ghanti*, *angoori*) and non-alcoholic (*sidu*, *bhatura*, *seera*) have been consumed throughout the state since time immemorial (**Bhatia *et al.*, 1977; Thakur *et al.*, 2004; Savitri and Bhalla, 2007; Kanwar *et al.*, 2011; Joshi *et al.*, 2012**). Among these, alcoholic beverages are attracting the attention of researchers because of their wide variability, popularity and acceptance among the tribes. However, the production of these beverages is confined to the specific or local areas according to the availability of raw materials such as *angoori* (grapes) is prepared in Kinnaur; *chhang* (barley) in Lahulspiti; *sur* (finger millet) in Kullu, Mandi and Kangra; *lugdi* (rice) in the Kangra, Kullu and Mandi (**Thakur *et al.*, 2004; Senthilkumar, 2009; Kanwar *et al.*, 2011; Joshi *et al.*, 2015**). These beverages have an aesthetic appeal as well as a religious and sociocultural value. For instance, *sur* is offered to local gods like *Hurang Narayan* and *lugdi* is sprinkled on the guests to welcome them (**Savitri and Bhalla, 2007; Joshi *et al.*, 2015**). As per the traditional knowledge available, these beverages possess numerous health benefits such as improving digestion, treatment of stone and jaundice (**Das *et al.*, 2012**).

Different researchers have already mentioned *lugdi* in literature as an alcoholic traditional beverage (**Bhatia *et al.*, 1977; Thakur *et al.*, 2004; Savitri and Bhalla, 2007; Kanwar *et al.*, 2011**) but a detailed study is still lacking which needs to be explored. *Lugdi* is also known as *jhol* and is a popular low alcoholic drink in Palampur region of Kangra district. Besides its intoxicating and health properties, it also has socio-cultural value. Hilly areas have witnessed a significant change in alcoholic beverage consumption behaviour; however, this beverage is still popular among local folks. Starting from household, *lugdi* production has its identity in small-scale industries. Still the uniformity and quality of the product is an issue and scientific interventions are needed to improve the quality and maintain the identity of product for longer time. Therefore, the present study was designed to point out the basic steps of its production along with its analysis with the aim of fulfilling this research gap.

STUDY SITE

Palampur is a tehsil and city in the Kangra district of Himachal Pradesh, India. It is situated 25.2 Km west to Kangra city and has an area of 429 Km^2 including 428.62 Km^2 rural area and 0.67 Km^2 of the urban area (**Anonymous, 2018a**). It extends between 32.11°N latitude to 76.53°E longitude. The mean annual temperature of Palampur is 19.1°C, which ranges from a minimum of 9.9°C in January to maximum of 27.1°C in June (**Anonymous, 2018b**).

METHODOLOGY

Survey

A field survey using an open-ended pretested questionnaire was conducted in the Palampur region (Banodoo, Paraur, Bandla, and Paprola) of the district Kangra, Himachal Pradesh, India. The workers in the production unit were interviewed regarding the production (inocula, processing steps), sale, consumption pattern and the believed positive health benefits (trusted positive medical or health benefits) of *lugdi*. The customers were also explored for the reasons of *lugdi* consumption.

Procurement and analysis of samples

Freshly prepared *lugdi* was sampled from different *lugdi* production units in sterilized bottles of 200 mL capacity and analysed for various quality attributes under laboratory conditions within three days of procurement. Physico-chemical characteristics *viz.* total soluble solids, total solids, titratable acidity, and pH were analysed as per the standard methods (**AOAC, 1984**). Reducing sugar was estimated by di nitro salicylic acid method while, total sugars were determined using phenol sulphuric method (**Sadasivam and Manickam, 1991**). Ethanol was measured colorimetrically by potassium dichromate method (**Caputi *et al.*, 1968**). Protein content was determined as per the standard procedure proposed by Lowry (**Sadasivam and Manickam, 1991**) while, amino acids were measured by the ninhydrin method (**Lee and Tunekazu, 1966**). Fusel alcohols were measured by the method given by **Guymon *et al.* (1961)**. Total phenols were measured

colorimetrically using gallic acid as standard (**Singleton and Rossi, 1965**), total esters were measured by the method given by **Liberty (1961)**.

Fourier Transform Infrared Spectroscopy (FTIR)

The collected samples of *phab* and *lugdi* were analysed qualitatively using FTIR analyser (Shimadzu 8400S FTIR spectrometer, equipped with KBr beam splitter). *Phab* was ground to a fine powder using lab scale grinder while *lugdi* was filtered through whatman filter paper and was dried at room temperature (30-35°C). Approximately 5 mg of each sample along with 5 mg KBr was used for analysis and FTIR spectrophotometer was operated at a spectral range of 4000-400 cm^{-1} with a maximum resolution of -0.85 cm^{-1}. The spectra obtained for the samples were interpreted by following the guidelines given by **Stuart (2004)**.

Sensorial analysis

To conduct the onsite sensory evaluation of *lugdi*, a local panel of the consumers was constituted. The panel was provided with a sensory proforma describing the terminology for colour, appearance and taste. The samples of the *lugdi* were served and the members of panel were asked to give their response on the proforma as per the standard procedure (**Joshi, 2006**).

Statistical analysis

The information generated from the survey is presented in tabular form or flowsheets while data obtained from the physico-chemical analysis was analyzed using Graph Pad Prism (La Jolla, CA, USA) software. The results are expressed as means ± standard deviation of the respective measures.

RESULTS

Production of *lugdi*

As per the information obtained in survey, *lugdi* has been produced at both household and commercial levels. Commercial production of *lugdi* was limited to the Palampur region of district Kangra, Himachal Pradesh. In this region four small scale *lugdi* production units were located at Banodoo, Paprola, Paraur and Bandla. General information of the *lugdi* production process has been provided in Table 1.

Table 1 General information on *lugdi* preparation in different small scale commercial units of Kangra, Himachal Pradesh (n=4)

Process Variables	Observations
Raw material	Broken rice
Inoculum type	*Phab*
Utensil used to carry fermentation	Earthen pots
Lot preparation	20-35 kg
Inoculum used	1-1.5% or 300-500 g/35 kg
Temperature for inoculum addition	Lukewarm (28-32°C)
Saccharification (duration)	Summer- 2-3 days Winter- 6-7 days
Fermentation (duration)	Summer- 2-3 days Winter- 6-7 days
Filtration	**1st filtration-** with locally made sieve by cutting and puncturing plastic cans **2nd filtration-** nylon sieve for fine filtration
Recovery	100-110 litres per 35 kg batch
Bottling	In cleaned glass bottles
Sale	30-40 INR per 700 mL bottle
Storage life	2-3 days in summers; 6-7 days in winters
Residue utilization	Animal feed

Where, n = number of *lugdi* production units covered under study

Raw materials

The survey revealed that broken rice was used as the main substrate for commercial production of *lugdi* (Table 1). The reason for the use of broken rice might be the less cost of brokens as compared to head rice. The results of present study were in agreement with **Senthilkumar (2009)**, who reported the use of local rice varieties like *Ram juvanae*, *Totu*, *Gharsai*, *Chinnu*, *Zhinni* and *Pandpermal* in *lugdi* production.

Inoculum

Phab, crude inocula was used to carry out the fermentation in all the production units covered under the present study. It was not prepared locally or *insitu* but was procured from the *Khampas* of Sidhbaddi (Dharamshala) region of Himachal Pradesh. These results are in corroboration with the findings of **Thakur *et al.* (2004); Senthilkumar (2009); Kanwar *et al.* (2011)**. In earlier studies, **Bhatia *et al.* (1977); Angmo and Bhalla (2014)** have discussed the *phab* production process in detail.

Production process

The detailed process of *lugdi* production has been provided in figure 1(a, b and c). Depending upon the local demand a batch of 20-35 kg of rice was being cooked in a big vat (Figure 1b) on a traditional wooden *chullah* or gas stove to a point of softness except the Paprola unit where rice was overcooked till the browning of the outer layer to impart good colour and flavour in the final product. The development of colour and flavour might have been due to the caramelization of sugars as the decomposition of sugars results in the formation of volatile and brown-coloured compounds (**Kroh, 1994**). The cooked rice was spread in a thin layer and cooled to about 28-32°C. *Phab* granules were ground to a fine powder and mixed uniformly at the rate of 350 g-500 g per 35 kg of cooked and cooled rice. The prepared mixture was filled in pre-sterilized earthen pots (20 L approx.) with the capacity of $1/2^{nd}$-$3/4^{th}$ of total volume, capped tightly with clothes and covered with gunny bags or woollen clothes to provide the required incubation temperature to facilitate the saccharification. The saccharification was allowed for 2-3 days in summers and 6-7 days in winters or until the mixture was converted to a cream-like slurry. After the completion of saccharification, the slurry was transferred (3-4 kg) to sterilised earthen pots (20 L approx.). To the slurry, water was added up to the brim and the mixture was allowed to ferment (2-3 days during summers and 6-7 days in winters). The increased fermentation rate during the summers might have been due to the shortening of lag phase as the lag phase decreases with increase in temperature (**Merrit, 1966**). During fermentation, the mouth of the pot was left uncovered and the absence of air bubbles on the top of the pot was used as an indicator for completion of fermentation.

Filtration

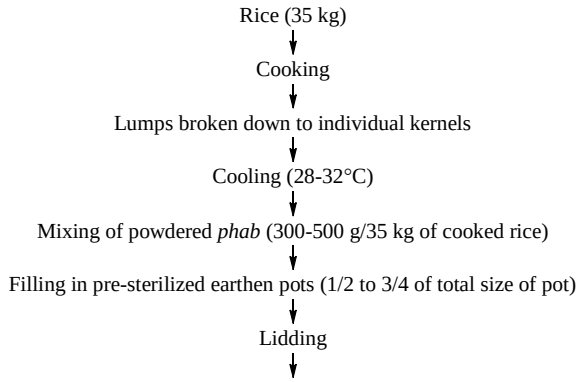
After completion of fermentation, the fermented material was filtered to separate *lugdi* from the spent material. The filtration was a two-step process involving coarse and fine filtration. Coarse filtration was carried out with a large sieve made by cutting plastic cans from one side and engraving holes on the other side (Figure 1c). It was followed by a fine filtration with a fine mesh strainer to get the clear product, which was further filled, into pre-washed glass bottles.

Sensorial analysis

Onsite sensory analysis of the samples revealed that product had a turbid appearance with colour ranging from white to yellowish white (Table 2). The turbid appearance might be due to the presence of unfermented starch in the drink as starch produces a turbid solution (**Sandhu and Singh, 2007**) whereas the difference in colour might be due to the caramelization of rice as discussed earlier. The flavour of collected samples varied from a sweet alcoholic to sour alcoholic depending on the freshness of the sample i.e. freshly prepared samples had a sweet alcoholic taste whereas stored samples were sour alcoholics (Table 2). The development of sour taste might be due to the growth of lactic acid along with fermentation as the *phab* contains a mixed microflora i.e. *Saccharomyces cerevisiae* and *Lactobacillus* species (**Joshi and Sandhu, 2000; Thakur *et al.*, 2004; Joshi, 2016**).

End use

As per the survey, it was observed that *lugdi* was not pasteurized and had a shelf life of 2-3 days in summers and 6-7 days in winters. The reason for not pasteurizing *lugdi* might be the lack of pasteurization facilities at the production units. It was also observed in the survey that product had a good demand in Palampur region and was sold onsite at a sale price of INR 30-40 per 750 mL bottle. The spent material was used as a feed for the mules (Figure 1c).



Fermentation
(2-3 days in summer and 6-7 days in winter or till a creamy product is obtained)
↓
Transfer 3-4 kg of this creamy product to other pots
↓
Filling the pot with water
↓
Fermentation
(2-3 days in summer and 6-7 days in winter)
↓
Filtration
↓
Filled into bottles
↓
Consumption
(Fresh or within 2-3 days of production)

Figure 1a Flow diagram of the traditional technology of the *lugdi* production as per the information gathered from *lugdi* production units

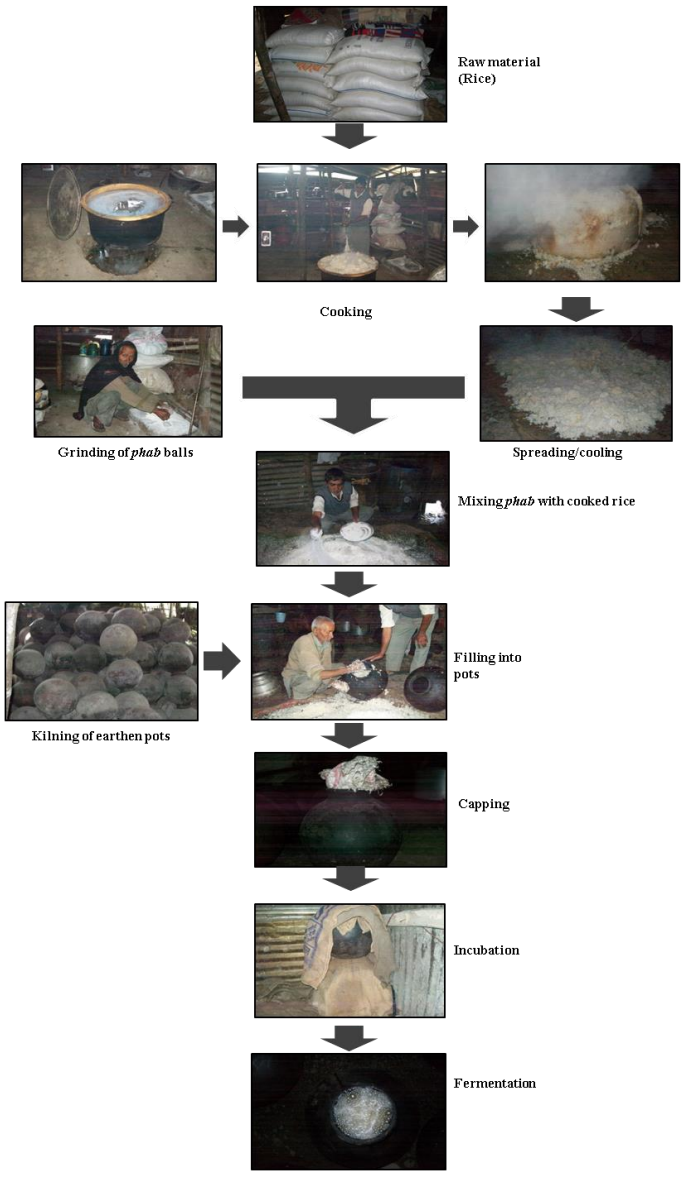


Figure 1b Pictorial representation of *lugdi* production process at small-scale commercial units

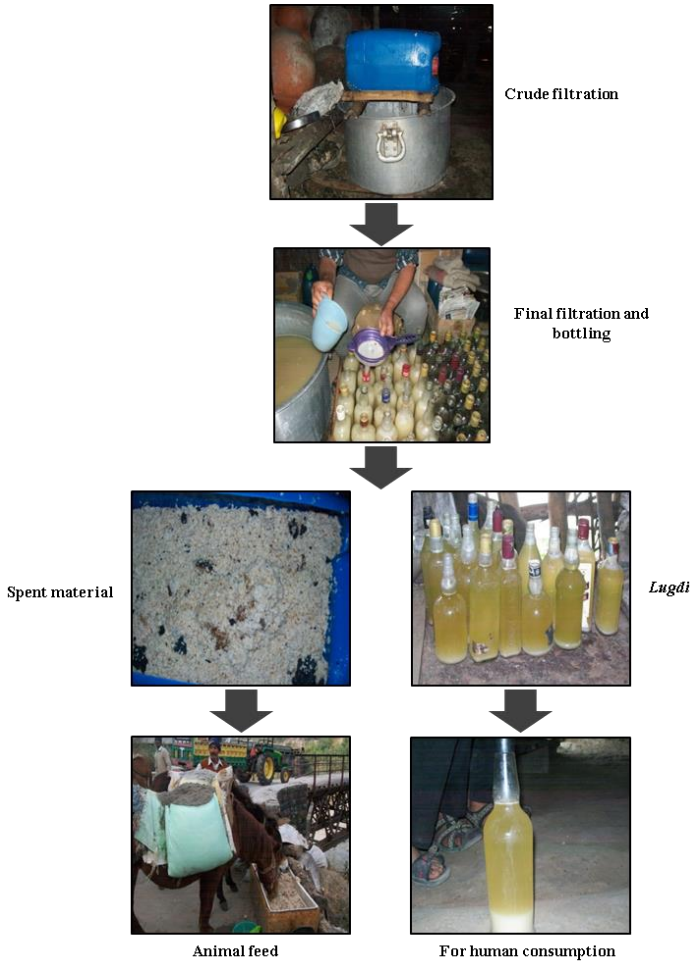


Figure 1c Pictorial presentation of filtration process and end-use of *lugdi*

Table 2 Sensory attributes of the collected *lugdi* samples

Sensory Parameters	Observation
Colour	White to yellowish white
Appearance	Turbid with starch settled at the bottom of bottle
Aroma	Acido-alcoholic (mixture of acid and alcohol)
Taste	Sour with the lingering taste of starch

Table 3 Physico-chemical attributes of collected *lugdi* samples

Parameters	Range	Mean Values
Total solids (%)	6.3-7.8	6.83±0.35
TSS (°B)	2.5-3.9	3.03±0.75
Reducing sugars (%)	0.15-0.42	0.28±0.08
Total sugars (%)	0.48-0.72	0.68±0.19
Ethanol (%v/v)	4.61-5.68	5.14±0.53
Colour (O.D.)	0.362-0.380	0.371±0.09
pH	2.82-3.55	3.08±0.41
Acidity (% as lactic acid)	0.83-1.15	0.97±0.18
Total proteins (mg/100 mL)	568.42-618.24	592.32±24.97
Free amino acids (mg/100 mL)	272.45-315.68	295.5±21.75
Total phenols (mg/100 mL)	127.56-168.54	148.58±20.51
Total esters (mg/100 mL)	85.34-108.78	96.93±11.72
Fusel alcohols (mg/l00 mL)	22.48-32.94	27.59±5.23

Physicochemical characteristics of collected *lugdi* samples

The collected *lugdi* samples were analysed for the different physicochemical parameters (Table 3), which revealed a wide variation even among the batches of

the product prepared in the same unit. This variation might be due to the non-standardized process and recipe used for *lugdi* production. Among the collected samples, total solids ranged from 6.3% to 7.8%, total soluble solids ranged from 2.5 to 3.9°B, total sugars were in between 0.48% to 0.72% and reducing sugars was in the range of 0.15% to 0.42%. The results of these parameters were in agreement with the results reported by **Senthilkumar (2009)**. The ethanol content of the product varied from 4.61% to 5.68%. **Kanwar *et al.* (2011)** had reported similar ethanol content in *lugdi* samples collected from LahulSpiti, Himachal Pradesh (India). However, **Thakur *et al.* (2004)** had reported a higher ethanol content of 8.5% in *lugdi* samples collected from Kullu district of Himachal Pradesh (India). Analysis also revealed pH, titratable acidity, protein, total phenols, esters and fusel alcohol in the ranges of 2.82 to 3.55, 0.83 to1.15% as lactic acid, 568.42 to 618.24 mg/100 mL, 49.1 to 100.7 mgGAE/100 g, 85.34 to 108.78 mg/L and 22.48 to 32.94 mg/L, respectively. A pH of 3.21 and titratable acidity of 0.20% has been reported by **Tamang and Thapa (2006)** in *bhattijannr* (a fermented rice beverage of north India). Chiang *et al.* (2006) reported a pH of 3.4 and acidity of 0.86% in *tapai* (an alcoholic beverage prepared from glutinous rice). *Phab* might be the major source of phenolics in the *lugdi* as *phab* consists of several herbs (as information gained during the survey). Esters are synthesized by yeasts during fermentation *via* several complex pathways (**Saerens *et al.*, 2010**). The wide variation in the physicochemical attributes of the collected samples might be due to the non-standardized recipe and local variation in process of the *lugdi* production.

FTIR characterization

FTIR spectrophotometer is among one of the most important analytical tools used to study physiochemical and conformational properties of wide range of samples including food (**Stuart, 2004**). The infrared spectra of *phab* and *lugdi* have been provided in (Figure 2a and 2b). The area of the respective peaks (*phab* and *lugdi)* is tabulated in Table 4. FTIR wave numbers are associated with the absorption bands of the compounds present in the foods. The interpretation of the peaks confirmed the presence of numerous nutritional and phytochemical compounds including sugars, amino acids, amides, aliphatic compounds, phenols and alcohols. **Panda *et al.* (2014)** reported similar functional compounds on FTIR analysis of bael wine.

Table 4 FTIR spectra of *phab* and *lugdi*

Sr. No.	*Phab*			*Lugdi*		
	Peak	**Area**	**Compound**	**Peak**	**Area**	**Compound**
1	420.5	19.14	KBr	514.05	7.486	KBr
2	521.76	48.691	KBr	1034.84	33.895	Alcohols, C=C-CH_2-OH, C-O stretch (phenolics)
3	575.77	48.283	NaCl	1254.74	6.156	Alcohols, phenols, Ar-O-H, C-O stretch
4	762.87	63.167	Aromatic compounds C-H bend	1463.06	6.841	Alanine, valine
5	860.28	40.29	β-D-Sucrose, β-D-glucopyranoside	1547.93	7.554	Protein amide II
6	930.68	50.758	Carboxylic acids C–O–H out-of-plane bending	1647.26	8.821	Proteins
7	1021.34	171.132	Phenols C-O stretching, O-H aromatic	1739.85	5.625	Carbohydrates, aldehydes and ketones aliphatic aldehyde C=O stretching
8	1154.43	73.021	Cellulose	1835.33	3.878	C=O stretching (carbonyl group)
9	1458.23	20.931	Alanine, valine	2361.91	10.574	X-H stretching, X is phosphorus or silicon
10	1539.25	18.343	Lysine, protein, amide II	2927.08	31.278	O-H stretching (carboxylic acids), aliphatic compounds
11	1651.12	21.561	Proteins, amide I	3619.54	7.21	O–H stretching (phenols)
12	2362.88	41.079	X-H stretching, X is phosphorus or silicon	3743.96	10.776	O–H stretching (water)
13	2927.08	173.138	O-H stretching (carboxylic acids), aliphatic compounds	3848.12	3.638	X-H stretching region
14	3342.75	5.326	O–H stretching (water)			

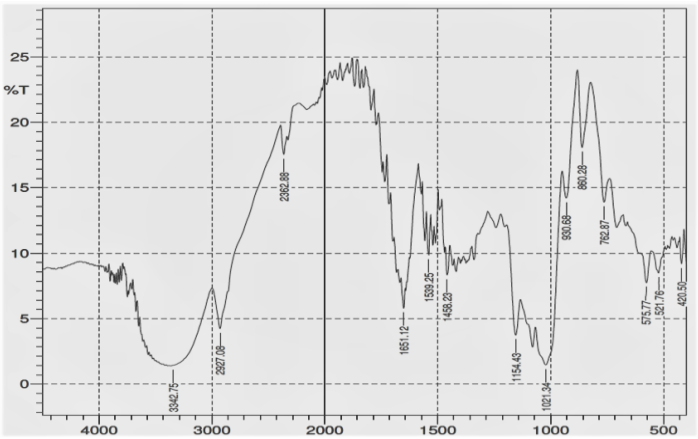


Figure 2a FTIR spectra for *phab*

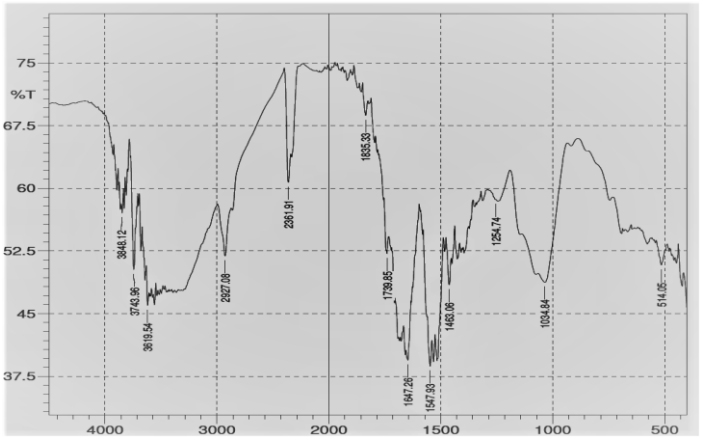


Figure 2b FTIR spectra for *lugdi*

CONCLUSION

Production and consumption of *lugdi* is an inherent part of the traditional culture of Palampur, Himachal Pradesh, India. Physicochemical and FTIR analysis of the product confirmed that it is a rich source of nutrients and phytochemicals like amino acids and phenolics, which strengthen its traditional claim of numerous health benefits. However, the availability of the commercial beverages and

reluctance of the new generation to get involved in the production of these beverages has put the traditional heritage under threat. It was concluded from the present study that the *lugdi* production process was not standardized and varied from place to place. Physicochemical analysis has also revealed a wide variation among the composition of the samples. Therefore, there is a need for an intervention by regulatory bodies to standardize the recipe and production process to produce a uniform product in terms of ethanol and other alcohols. This could also help in shielding the rich traditional heritage of the state.

CONFLICT OF INTEREST

There is no conflict of interest among authors.

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